

PETER G. MORROS, Director  
L.H. DODGION, Administrator

(702) 687-4670  
TDD 687-4678

Administration  
Mining Regulation and Reclamation  
Water Pollution Control  
Facsimile 687-5856

STATE OF NEVADA  
BOB MILLER  
Governor



Waste Management  
Corrective Actions  
Federal Facilities  
Facsimile 885-0868

Air Quality  
Water Quality Planning  
Facsimile 687-6396

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES  
DIVISION OF ENVIRONMENTAL PROTECTION

333 W. Nye Lane, Room 138  
Carson City, Nevada 89706-0866

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DATE: 10/8/97

TO: Kevin Mayer

FAX NUMBER: 415-744-2180

FROM: Doug Zimmerman

SUBJECT/COMMENTS: Kerr McBee report

NUMBER OF PAGES INCLUDING COVER PAGE: 20

IF YOU HAVE ANY QUESTIONS CALL: (702) 687-4670 EXT 3127

**KERR-MCGEE CHEMICAL CORPORATION**

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October 1, 1997

Brenda Pohlmann  
Remediation Branch Supervisor  
Nevada Division of Environmental Protection  
555 East Washington, Suite 4300  
Las Vegas City, NV 89101

Dear Ms. Pohlmann:

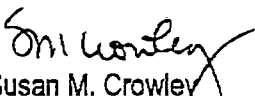
Subject: KMCC Perchlorate Groundwater Sampling Report

Kerr-McGee submitted a Sampling Plan for preliminary characterization of perchlorate impact of groundwater at the Henderson Nevada facility. This Sampling Plan described field work designed to identify groundwater quality in the areas where perchlorate has been present. Nevada Division of Environmental Protection reviewed this Plan and field work was conducted in August 1997.

Enclosed are two copies of the Report describing the field work and summarizing the resulting analytical information.

Please feel free to contact me at (702) 651-2234 if you have any questions.

Sincerely,

  
Susan M. Crowley  
Staff Environmental Specialist

Enclosures (2)

By certified mail

cc: LKBailey  
PSCorbett  
PBDizikes  
RHJones  
RANapier  
MJPorterfield  
TWReed  
EMSpore  
BZMeyer (NDEP)

Groundwater Investigation for Perchlorate Impact at  
Kerr-McGee Chemical Corporation  
Henderson, Nevada

October 1, 1997

Prepared by  
Kerr-McGee Chemical Corporation  
8000 West Lake Mead Drive  
Henderson, NV 89015

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Kerr-McGee Chemical Corporation

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## CERTIFICATION PAGE

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state and local statutes, regulations and ordinances.

Date: October 1, 1997

Name: Susan M. Crowley

Signature: \_\_\_\_\_

Certificate Number: EM-1428

Expiration Date: March 8, 1999

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## 1.0 INTRODUCTION

### 1.1 Objectives

Kerr-McGee Chemical Corporation (KMCC) conducted field and analytical work at KMCC's Henderson, Nevada facility to provide information about groundwater impact by perchlorate ion. This report describes the fieldwork and analyses performed and summarizes the analytical information obtained.

### 1.2 Scope of Work

The scope of work included sampling and analysis of 47 on-site groundwater monitoring wells. Analyses were performed to evaluate perchlorate impact at the Henderson site. This report summarizes the results of the sampling and analyses.

### 1.3 Report Format

Section 1.0 of this report presents the overall objectives of this sampling effort and outlines the scope of work. Section 2.0 discusses and reviews site location and history and physical site characteristics. The field work completed during this sampling effort is detailed in Section 3.0, and the laboratory results are presented and discussed in Section 4.0. Section 5.0 includes a discussion of the data validation performed on analytical data, and Section 6.0 lists the references used for this report.

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## 2.0 PROJECT BACKGROUND

### 2.1 Site Location and History

The KMCC property, which is part of the BMI complex, is located approximately 13 miles southeast of Las Vegas in an unincorporated section of Clark County Nevada, and is completely surrounded by the incorporated area comprising the City of Henderson (Figure 1-1). Originally sited and operated by the U.S. government as a magnesium production facility, the BMI complex operated from August 1942 to November 1944 in support of the war effort.

When the magnesium operations ceased, a portion of the BMI complex was leased from the government by Western Electrochemical Company (WECCO) in 1945. Western Electrochemical Company was the first company to produce inorganic chemicals, such as chlorates, perchlorates, and manganese dioxide, at this location. By 1952, WECCO had purchased various portions of the complex. In 1955, WECCO merged with American Potash and Chemical Company (AP&CC) and continued to produce similar chemicals. In 1962, AP&CC purchased the current ammonium perchlorate plant, sodium perchlorate plant, and half of the sodium chlorate plant from the U.S. government. KMCC acquired AP&CC by merger in 1967. Subsequently, KMCC acquired the remainder of the sodium chlorate plant. In addition to the production of chemical oxidizers, the facility also produces manganese dioxide and boron-based products.

### 2.2 Physical Site Characteristics

#### 2.2.1 Geology

The BMI complex is located in the south-central portion of the Las Vegas Valley. The Las Vegas Valley lies within the Basin and Range physiographic province which consists of desert basins with interior drainage flanked by sparsely vegetated mountains. The valley is wide, flat, and slopes southeasterly from an altitude of about 2,000 feet above mean sea level (msl) at Las Vegas to about 1,200 feet at Lake Mead. Mountains composed of igneous and sedimentary rocks rise steeply along the borders of the valley and coalescing alluvial fans slope gently from the mountains toward the valley floor.

The Las Vegas Wash, a shallow, narrow stream that flows southeasterly across Clark County, drains into Lake Mead. The KMCC property is approximately three miles south of the Las Vegas Wash.

The elevations on the KMCC property range between 1,600 and 1,800 feet above msl. The site rests on top of alluvial deposits, originating from the McCullough Range, that slope gently to the north toward the Las Vegas Wash.

Sediments beneath the site consist of alluvial deposits which include a reddish-brown, heterogeneous, well-graded mixture of sand and gravel with lesser amounts of silt, clay, and caliche. Boulders and cobbles are common. Due to their mode of deposition, no distinct beds or

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units are continuous over the area. Distinct layers are only present in the form of gravel beds cemented with caliche in the northwest corner of the site (Jacobs Engineering, October 1987).

Generally, the alluvial deposits thicken from south to north beneath the facility. These deposits are of greater thickness over the erosional channels in the underlying sediments and are thinner over intervening interfluvial areas. The thickness of the alluvial deposits ranges from approximately 19 to 62 feet beneath the KMCC facility (Kleinfelder, 1993).

A major feature of these alluvial deposits is the stream-deposited sands and gravels that were laid down within the old channels developed on the surface of the Muddy Creek formation during infrequent flood runoff periods. These deposits conform to the old channel boundaries, which were characteristically linear and narrow in configuration. These channel fill deposits are typically uniform sands and gravels and show higher permeability than the adjacent well-graded alluvial deposits. The importance of these channel fill deposits is that they control the occurrence and movement of groundwater in this portion of the Las Vegas Valley (Hydrologic Investigation, KMCC, July 1985).

No distinct lithologic contacts exist between the Muddy Creek formation and overlying alluvial sediments; however, a 5-foot thick transitional zone has been reported to occur above the Muddy Creek formation where small white clayey silt lenses are interbedded with sand and gravel (Jacobs Engineering, October 1987).

## 2.2.2 Groundwater

The KMCC facility resides within the Las Vegas Valley. Groundwater in the Las Vegas Valley occurs mainly in the unconsolidated sediments of the valley fill. The upper alluvium, although well graded, is able to store and transmit relatively large quantities of groundwater. The hydraulic properties of this unit vary due to its lithologic heterogeneities. The hydrologic characteristics of the near-surface alluvial aquifer vary due to the presence of high permeability zones. These zones are paleo-channels of unconsolidated gravels and streambed deposits. The zones trend north-south reflecting past regional drainage patterns. The transmissivity of these buried channels is much greater than the values determined for the overall alluvial material and is due to the high energy nature of deposition. The transmissivity of the remaining alluvial deposits is low due to the poorly sorted nature and the limited saturated thickness.

Three artesian or confined aquifers that make up the lower confined aquifers are identified in the Las Vegas Valley. These aquifers are coarse-grained facies within the Muddy Creek Formation and are separated from each other by thick, massive layers of clay. The shallow artesian aquifer is located from depths of 200 to 450 feet, and consists of sand and gravel interbedded with clay and silt. At the base of the shallow artesian aquifer, a persistent layer of blue clay, which overlies the highly productive middle aquifer, is present. The middle aquifer is the principal source of groundwater pumped in the valley. A deep aquifer exists in the western half of the valley at depths of 700 feet and has been developed in recent years (1978). It is reported that the deeper confined sand zones in the Muddy Creek Formation have higher piezometric or artesian heads than the shallower confined zones.

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The depth to the upper alluvial aquifer varies over the KMCC site from 20 feet below ground surface (bgs) in the northern portion, to 90 feet bgs in the southern portion. The water quality of the upper aquifer is poor and the groundwater is not used. There are no wells on record within a 4-mile radius that draw water from the upper aquifer. Water is of poor quality due to natural conditions.

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## 3.0 SCOPE OF WORK

## 3.1 Sampling Locations

Well locations were selected to provide information about facility-wide groundwater quality. Well locations are shown on Plate 1. Table 1 lists the wells included in the sampling effort.

Table 1. Wells to be Sampled

Location	Well #
Facility Upgradient	M-10
North of Unit Buildings	M-11
	M-12
	M-13
	M-29
Leach Latitude	M-32
	M-50
	M-21
Steam Plant Latitude	M-35
	M-34
	M-2
	M-76
AP Plant Latitude	M-39
	M-89
	M-37
	M-17
	M-14
AP Pond Latitude	M-22
	M-36
	M-25
	M-62
Intercept Well Latitude	I-A to I-O (15 wells)
	M-57
Recharge Trench Latitude	M-88
	M-86
	M-83
	M-90
North Drainage Ditch Latitude	M-48
	M-23
	M-5A
	M-6A
	M-7A
North Property Boundary	M-44
	M-96

Please refer to the KMCC Phase II Work Plan for well construction details.

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### 3.2 Analytical Data

The general quality indicators, pH and specific conductance, were determined for each well location. In addition, concentrations of perchlorate and chlorate ions were determined. Table 2 lists the Methods used for each analyte.

Table 2. Methods of Analysis

Analyte	Method	Expected Detection Limit
pH	EPA 150.1	NA
Specific Conductance	EPA 120.1	<50 umhos
Perchlorate Ion	X1-C.7.5 * Ion Chromatography **	10 mg/l * 0.0007 mg/l **
Chlorate Ion	X1-C.7.1*	1 mg/l

\* KMCC Internal Method

\*\* State of California "Method for Perchlorate Analysis by Ion Chromatography"

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## 4.0 ANALYTICAL RESULTS AND SUMMARY OF FINDINGS

## 4.1 Analytical Results

Forty-seven groundwater monitor wells and recovery wells were sampled during the week of August 25, 1997. Well I-C was not sampled due to obstructions which have subsequently been repaired. Groundwater collected from these wells was analyzed for pH, specific conductivity, chlorate, and perchlorate. All groundwater sampling activities were conducted in compliance with the approved facility Sampling and Analysis Plan (SAP). Laboratory analytical results are included in Table 3.

Table 3. Analytical Results

Location	Well #	pH	Spec Cond (umhos)	Perchlorate (mg/l)
Facility Upgradient	M-10	6.93	3340	53
North of Unit Buildings	M-11	7.63	9350	260
	M-12A	7.22	24500	3400
	M-13	7.42	5880	81
	M-29	6.31	4270	<0.7
Leach Latitude	M-32	7.13	5810	870
	M-50	7.12	19100	1600
	M-21	7.35	4680	52
Steam Plant Latitude	M-35	7.23	6250	340
	M-34	7.05	13960	1100
	M-2A	7.34	11300	650
	M-76	7.57	8050	200
AP Plant Latitude	M-39	7.46	6330	110
	M-89	7.15	11600	1200
	M-37	6.94	18950	18000
	M-17	7.27	8980	880
	M-14	7.74	3240	28
AP Pond Latitude	M-22	7.24	11140	2800
	M-36	7.22	14400	2900
	M-25	7.35	9250	780
	M-62	7.72	3310	25
Intercept Well Latitude	I-A	7.78	4600	530
	I-B	7.17	4720	1400
	I-D	6.91	10400	1200
	I-E	7.19	9730	1100
	I-F	6.98	12300	2000
	I-G	6.95	11700	2300
	I-H	6.91	13480	2800
	I-I	7.24	10060	660

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Location	Well #	pH	Spec Cond (umhos)	Perchlorate (mg/l)
	I-J	7.38	6350	49
	I-K	7.26	12500	19
	I-L	7.14	5380	1500
	I-M	7.26	10050	1000
	I-N	7.12	10700	1600
	I-O	7.08	10850	2300
	M-57	7.76	3060	22
Recharge Trench Latitude	M-88	7.51	6840	23
	M-86	7.23	10930	1800
	M-83	7.19	10810	1400
	M-90	7.17	10090	1700
North Drainage Ditch Latitude	M-48	7.38	8440	630
	M-23	7.23	10650	1600
	M-5A	7.09	11000	<0.7
	M-6A	7.47	6120	<0.7
	M-7A	7.53	6370	47
North Property Boundary	M-44	7.41	10850	1400
	M-96	7.42	10900	1500

Chlorates were tested to ensure that there were no interferences to perchlorate assays. No interference effects were observed with chlorate values ranging from <3mg/l to 13,500 mg/l at well M12A.

#### 4.2 Summary of Findings

Isopleth maps have been prepared for perchlorate and specific conductance and are attached as Plates 1 and 2 respectively.

##### 4.2.1 Perchlorate Results

We do not believe that any of the perchlorate results are due to current operations, but rather represent past practices.

Plate 1 portrays the perchlorate groundwater sampling results. Two source areas of elevated perchlorate concentrations are noted at the site, one beneath Unit 4 in the southern portion of the facility, and another centered around monitor well M-37 in the northwest portion of the plant site.

Elevated perchlorate concentrations associated with Unit 4 and M-37 relate to historic practices. Unit 4 was utilized for perchlorate production beginning in 1945 and continuing for the first 30 years of production. The perchlorate concentrations move with the groundwater downgradient to

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the north and decline in concentration in a trend toward the north boundary of the facility (see Plate 1). At the facility boundary, concentrations were 1400 and 1500 mg/l.

#### 4.2.2 Specific Conductivity Results

The specific conductivity trend, shown on Plate 2, mirrors the perchlorate trends. The trend is elongated north-south in the direction of groundwater flow. The conductivity tends to moderate downgradient from the facility. Because the water table aquifer in this area is characterized by naturally-occurring dissolved solids, the specific conductivity will tend to increase naturally as groundwater flows downgradient to ultimate discharge in Las Vegas Wash.

#### 4.3 Facility Groundwater Recovery System Evaluation

The KMCC Henderson facility currently operates and maintains a groundwater pumping system for the recovery and treatment of chromium impacted groundwater in the water table aquifer. A series of 15 recovery (interception) wells are installed along an east-west line to intercept impacted groundwater moving downgradient from the Unit 4 area. This line of interception wells is shown on Plate 1. These wells were installed at an ideal location and positioned spatially to adequately bracket the width and extent of the chromium groundwater plume.

A review of the perchlorate trends on Plate 1 indicates that the interceptor well placement line also adequately brackets these trends at that portion of the facility. The existing chromium treatment system effectively removes chromium from the recovered groundwater, however, the system is not designed to remove the perchlorate concentrations. Based on the location and placement of the existing interceptor wells relative to the perchlorate trends, it appears that this system would serve as an effective interception line for groundwater impacted with perchlorate.

#### 4.4 Technology Review

KMCC has initiated an investigation into treatment alternatives which could be used effectively to reduce perchlorate in the groundwater. A status of the investigation follows.

##### 4.4.1 Biodegradation

The use of bacteria has been shown to reduce perchlorate in water up to 15,000 ppm from bench scale to pilot scale. This technology is patented by the USAF and the transition to the private sector is under way. Patents in progress and pending in the private sector will make the industrial use of this technology easier. Treatability and operability testing is underway with our groundwater to characterize the necessary chemistry and economics of the anaerobic bioreactor. Pending successful testing of 2 months duration, a decision will be made regarding pilot and scale up of this technology.

##### 4.4.2 Catalytic Hydrogen Reduction

Hydrogen catalysis is a rather large body of scientific study. Hydrogen ion can be used to reduce chlorate and perchlorate in a catalysis reactor. Reactor (bench scale) design is underway and

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testing will continue for about 2 months duration. The proper catalyst for reaction with hydrogen in the presence of our groundwater is necessary for successful reduction of the chlorate and perchlorate contaminants. There also exists the possibility that electrochemical enhancement of the hydrogen catalysis reactor may be successful. Pending successful testing of either or both of these methods, scale up and evaluation will then be made.

#### 4.4.3 Electrochemical Reduction

Utilizing proper current densities and preconcentration of the perchlorate and chlorate ions, reduction could be effected in an electrochemical cell. Chlorate reduction has been shown to occur on an iron cathode under the right environmental conditions. Perchlorate may also be reduced with the proper selection of cathode materials, such as tin, and precious metals, with minimal environmental effects. Low concentration of wastewater chlorate and perchlorate cannot be reduced because of diffusion control at the surface of the cathode due to hydrogen production. The use of an air cathode may eliminate this problem and solve the reduction problem. If these tests are successful, then further evaluation and scale up will be made.

#### 4.4.4 Reverse Osmosis

Reverse Osmosis may be used to remove the chlorate and perchlorate from the groundwater. This is not a destruction technology and will have to be operated in concert with another destruction process. It is possible that the use of reverse osmosis membranes can be used with electrochemical reduction to effect concentration of chlorate and perchlorate for final reduction. Testing is underway to assess the level of removal of chlorate and perchlorate from the groundwater. Membrane selection and testing will take about 2 weeks to determine with testing beginning in October. Pending successful selection of a membrane and testing, further evaluation will be undertaken.

#### 4.4.5 Ozonation

Ozonation has been discussed as a possible reduction method which has been successful with some chlorate streams from pulp mills. This is a technology which has not been tested with reduction of perchlorate. The levels of concentration of chlorate and perchlorate are not known at which ozonation is successful. This technology could be used with an RO system if proven successful in reduction. Testing of ozonation will be conducted in October on the groundwater sample of chlorate and perchlorate. If this technology is successful, it will be evaluated with an RO system as pre-treatment.

#### 4.4.6 Granular Activated Carbon

Granular Activated Carbon (GAC) has been used semi-successfully at a water treatment plant in Southern California for removal of perchlorate from well water. The mechanism of this process is unknown, although speculation is that bacteria from groundwater is attaching itself to the organic carbon and reaction with perchlorate is a secondary reaction at the surface of the carbon. Further test work on carbon type with our groundwater will be completed in October to determine if the

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reaction can be duplicated with our groundwater and bacteria to reduce chlorate and perchlorate. Further tests and evaluation will be made if this method is successful.

#### 4.4.7 Ion Exchange

Ion Exchange (IX) can be used to remove chlorate and perchlorate from groundwater, although preconcentration may have to be made. IX does not reduce the perchlorate, but does remove it from the water. Testing will be accomplished during the next 2 month period to determine IX's effectiveness in removal of both ions. Further tests and evaluations will be completed if the method is found to be successful.

#### 4.4.8 Ecological Systems

Initial planning is underway to test an ecological system for reducing chlorate and perchlorate. This process uses the natural plants and bacteria to reduce chlorate and perchlorate and remediate the resultant sludge from the bacteriological process. This method is in the early stages of development and will be tested if the preliminary bench scale tests are found to be successful. This process is very successful with food wastes, but has minimal industrial applications, because it is very new (1992). If further testing is warranted beyond the bench scale, pilot testing will be needed to prove performance before full scale implementation.

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## 5.0 DATA VALIDATION AND REVIEW

The following QC procedures were followed for the analysis of Henderson groundwater samples of perchlorate content by Ion chromatography (IC) and Ion selective electrode (ISE).

5.1 Calibration Standards:

- 5.1.1. Potassium perchlorate salts were purchased from two different sources.
- Aldrich: 24,183-0; 99+%, ACS Reagent.
  - Aesar: 11630; 99-100.5%, ACS Reagent.
- 5.1.2. Calibration standards for each technique (IC and ISE) were prepared from each of the two primary salts. Calibration standards (Aesar) were verified with check standards (Aldrich); agreement was within the control limit of 5% relative for each set.

5.2 Analysis (IC and ISE):

- 5.2.1. The following QC samples were analyzed at the start and end of each analytical run and after every 20 samples.
- Duplicate: Control Limit of  $\pm 20\%$  RPD.
  - Spike: Control Limit of 80-120% Recovery.
  - Mid-point Calibration Check Standard: Control Limit of  $\pm 10\%$  relative.
  - Reagent Blank: Results were <IDL.
- 5.2.2. The following representative samples from this set were analyzed by ISE at different dilutions and by IC.

Well	ISE Analysis	ISE Duplicate Analysis at Higher Dilution	IC Analysis
M37	18,000 mg/l (100 x dil)	18,000 mg/l (2000 x dil)	19,000 mg/l (200,000 x dil)
M36	2,900 mg/l (10 x dil)	3,000 mg/l (100 x dil)	2,800 mg/l (20,000 x dil)
I-H	2,800 mg/l (10 x dil)	3,000 mg/l (100 x dil)	3,100 mg/l (20,000 x dil)
M10	53 mg/l	56 mg/l (10 x dil)	55 mg/l (1,000 x dil)
M21	52 mg/l	54 mg/l (10 x dil)	51 mg/l (1,000 x dil)
M29	<0.7 mg/l	—	0.2 mg/l
M5A	<0.7 mg/l	—	0.2 mg/l
M6A	<0.7 mg/l	—	0.5 mg/l (2 x dil)

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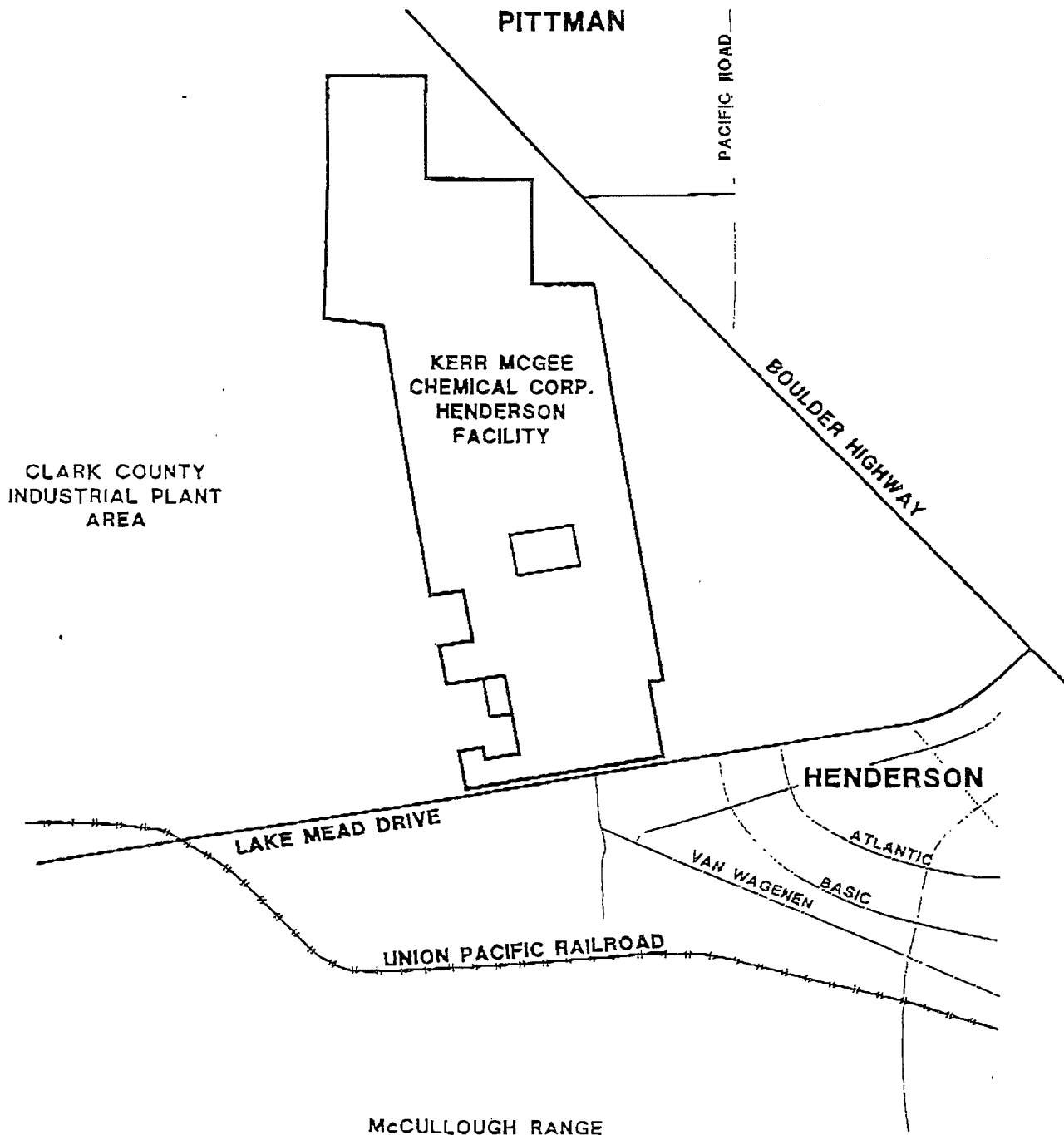
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## 6.0 REFERENCES

"Method for Perchlorate Analysis by Ion Chromatography, Rev 1," California Department of Health Services, State of California.

"Kerr-McGee Chemical Corporation Standard Operating Procedures," Volume XI, Laboratory Quality Manual, Kerr-McGee Chemical Corporation, Henderson, NV, 89009.

"Methods of Chemical Analysis of Water and Wastes," US Environmental Protection Agency, NERL, Cincinnati, OH 45268, March, 1983 (EPA-600/4-79-020).



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SCALE IN FEET

**ENSR**

FIGURE 1-1  
**SITE LOCATION MAP**

Kerr McGee Chemical Corporation  
Henderson, Nevada

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